(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 216 761 A1

(12) EUROPEAN PATENT APPLICATION

published in accordance with Art. 158(3) EPC

(43) Date of publication:
26.06.2002 Bulletin 2002/26

(21) Application number: **99956370.3**

(22) Date of filing: **09.08.1999**

(51) Int Cl.[7]: **B08B 3/02**, B63B 59/08, B63C 11/52

(86) International application number:
PCT/RU99/00277

(87) International publication number:
WO 01/10576 (15.02.2001 Gazette 2001/07)

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE

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(54) DEVICE FOR HYDRODYNAMIC CLEANING OF SURFACES AND VARIANTS

(57) The invention relates to the technology of hydrodynamic cleaning of surfaces of various facilities, enabling the service performance of the cleaning device to be improved. The inventive device comprises a body, a collector, a stator, a rotor comprised of radial piping and high pressure-flow generators. The body has the shape of a profiled disk and is partially filled with a mobile ballast. A platform with supports is mounted on the stator. The profiled rotor vanes create an underpressure below the body of the device. The limiting tilt angles between the flow generator nozzles and the surface to be treated are set by mathematical computation. An apparatus is used to modify the direction of movement of the entire cleaning device. Another embodiment of the invention is characterized in that the steering angle of the axis of generator jets is greater than zero degrees on a horizontal plane with respect to the axis of radial piping, in the direction of rotation of the rotor. The rotor is rotated by ejection jets, whereby said ejection jets are mounted on the radial piping of the collector rotor, at a right angle with respect to the axis thereof.

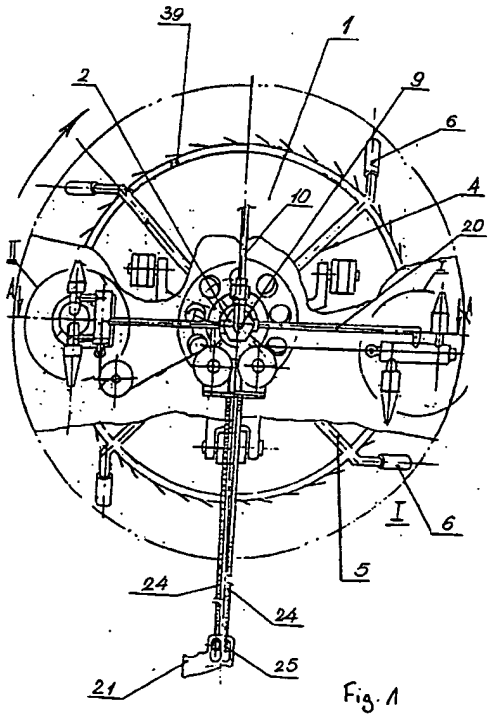

Fig. 1

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Description

[0001] The present invention relates to hydrodynamic surface cleaning technique applicable to cleaning various constructions and is concerned with variants of developing apparatus for such hydrodynamic cleaning. According to Variant I, the apparatus of the invention comprises a housing, header, stator, rotor appearing as a number of radial pipe-lines, and generators of high-pressure jets. The housing appears as a shaped disk partially filled with a shifting ballast. The stator carries a platform provided with supports. The profiled rotor vanes create a negative pressure beneath the housing of the apparatus. The distances between the injector and the extreme points of the pattern of the contact between the jet and the surface being treated are specified. Provision is also made for a device for changing the direction of motion of the entire cleaning apparatus. Variant II of the apparatus for hydrodynamic cleaning of surfaces is distinguished for the fact that the angle of turn of the axis of the generator nozzles in a horizontal plane with respect to the axis of the radial pipe-lines in the direction of the rotor rotation exceeds zero degrees. Rotation is imparted to the rotor by ejector nozzles, each of which is disposed on the radial pipe-line of the rotor header at the right angles to the axis thereof. A technical result of the practical implementation of the present invention with any variant of embodiment of the proposed apparatus for hydrodynamic surface cleaning consists in higher working reliability of the apparatus, as well as its higher effectiveness, throughput capacity, operating safety, and an extended range of surfaces to be treated, including work on land. Two sheets, 16 dependent claims, 13 drawings.

[0002] The invention relates to technological apparatus aimed at hydrodynamic cleaning of surfaces and can find application in designing and creating apparatus for cleaning, e.g., ships and submersible structures, waterworks, and any other surfaces from getting fouled with marine growth, corrosion, soiling, and other similar deposits accumulated on the surfaces to be treated both under water and on land.

[0003] Known from the present state of the art is a device for mechanical cleaning ships' hulls from getting fouled with marine microorganisms, said device comprising a disk-shaped housing and a rotatable rotor disposed underneath said disk-shaped housing and receiving rotation from a motor. The rotor appears as a number of radial scrapers producing mechanical action, when the rotor rotates, on foul deposits accumulated on the surface being treated for the surface to get rid of said deposits (cf. US Patent #4,372,242, IPC^{3}B 63 B59/00 (NPC 114/222), 1983).

[0004] Also known from the relevant prior art is hydromechanical device for cleaning underwater surfaces of ships, comprising a housing, hydraulic pump, disk-shaped brushes, and high-pressure nozzles for treating the surface being treated, as well as water-jet propelling nozzles for the device to move in water in various directions. The high-pressure nozzles have an adjustable setting angle, and the disk-shaped brushes have an adjustable angle of slope (cf. RU Patent #2,098,315, IPC^6 B 63 B 59/08, 1996).

[0005] Furthermore, one more hydrodynamic device for surface cleaning is known to comprise a housing carrying wheel-shaped supports, a ring header provided with high-pressure nozzles and communicating, via a reducer, with the central portion of the housing, and a hose connected to the source of high pressure which feeds the working fluid to the header. The header rotates by virtue of the reaction force of the jets discharging from the high-pressure nozzles which simultaneously clean the surface being treated (cf. US Patent #5,048,445, IPC^{5}B 63 B 59/00 (NPC 114/222, 1991).

[0006] However, all the above-mentioned analogs to the herein-proposed apparatus fail to attain the required technical result, this being due to an inadequate cleaning efficiency attainable by the mechanical mechanisms used, which in turn resulting from high-strength of foul deposits and a danger of damaging the surface being treated by mechanical scrapers. In the hydromechanical devices which make use a combination of the surface-cleaning brushes and of high-pressure jets of the working fluid the required technical results cannot be obtained due to a low efficiency of each of said components of the cleaning process, i.e., incomplete utilization of throughput capacity of the cleaning brushes and of the high-pressure jets. In addition, the known hydrodynamic device has a bulky complicated construction which affects adversely the effectiveness of the functional use of the device itself.

[0007] The closest technical solution selected as the prototype of both variants of the proposed invention, is a device for hydrodynamic surface cleaning, comprising a disk-shaped housing, a header accommodated centrally in the housing and consisting of a stationary fixed stator arranged along the housing axis, and a rotor rotating on the stator and disposed beneath the lower surface of the housing whose axis of rotation aligns with the axis of the housing appearing as a number of radial pipe-lines communicating with the ducts of the working fluid feed line, at the ends of which pipe-lines are disposed generators of the high-pressure jets, said generators being arranged in the horizontal and vertical planes and at an angle to the header axis; supports adapted to interact with the surface being treated; a reducer, and a piping to feed the working fluid from the high-pressure source to the header (cf. RF Patent #2,122,961, IPC^6 B 63 B 59/00, 1998).

[0008] Attaining the required technical result in the prototype for both variants of the proposed invention is impeded by an inadequate working efficiency of the device stemming from construction features of the rotor thereof; too a low throughput capacity and quality of surface cleaning; no provision for ballasting of the device which affects adversely its performance characteristics;

and the fact that the known device cannot be used for surface cleaning on land, e.g., in a dry dock.

[0009] It is a primary and essential object of the present invention is to provide an apparatus for hydraulic surface cleaning, featuring high operating efficiency and throughput capacity, ensuring safe operation and being equally operable both under water and on land for cleaning the surfaces of various constructions, buildings and structures.

[0010] The technical results attainable due to accomplishing said object of the present invention are as follows: higher operating reliability of the apparatus, as well as its efficiency, throughput capacity, working safety, as well as an extended range of surfaces being treated, including those carried out on land.

[0011] Said object is accomplished and the required technical result as per Variant I of the invention is attained due to the fact that in an apparatus for hydrodynamic surface cleaning comprising a disk-shaped housing, a header accommodated centrally in the housing and consisting of a stationary fixed stator arranged along the housing axis, and a rotor rotating on the stator and disposed beneath the lower surface of the housing whose axis of rotation aligns with the axis of the housing appearing as a number of radial pipe-lines communicating with the ducts of the working fluid supply line, at the ends of which pipe-lines are disposed generators of the high-pressure jets, said generators being arranged in the horizontal and vertical planes and at an angle to the header axis; supports adapted to interact with the surface being treated; a reducer, and a piping to feed the working fluid from the high-pressure source to the header, according to the invention, the housing appears as a hollow shaped disk having at least one lower shaped surface and partially filled with a shifting ballast, the housing has a number of ports disposed circumferentially in the central portion thereof, said ports being overlapped with ports similar as to disposing, shape and area and provided in a ring mounted rotatably on the top portion of the housing in the central portion thereof; the apparatus is further provided with: a platform carrying supports, said platform being mounted on the stator of the header and disposed beneath the rotor thereof; shaped vanes mounted on the rotor with a possibility of establishing a flow of the working fluid moving from under the lower shaped surface of the housing and directed from the center to the periphery thereof to create a negative pressure underneath the lower surface of the housing; and a device for changing the direction of motion of the apparatus, the injectors of the generator of high-pressure jets being set at an angle α to the surface being treated such that the borders of the contact pattern of the high-pressure jet of working fluid with the surface being treated, said contact pattern being shaped as an oval whose minor axis is equal to a maximum cross-sectional diameter of the flow body, are defined by the extreme points on the major axis of the ellipse removed from the exit section of the nozzle of the injector of the high-pressure jet generator a distance determinable from the following mathematical relationships:

$$L_{1max} = 0.8\, P_0 \cdot d_0$$

$$L_{2min} = 0.5\, P_0 \cdot d_0$$

where L_{1max} and L_{2min} (mm) state for the maximum and minimum distance, respectively;

P_0 is an inlet pressure of the injector;

d_0 is a minimum diameter of the injector flow section.

[0012] Said object is accomplished and the required technical result as per Variant II of the invention is attained due to the fact that in an apparatus for hydrodynamic surface cleaning comprising a disk-shaped housing, a header accommodated centrally in the housing and consisting of a stationary fixed stator arranged along the housing axis, and a rotor rotating on the stator and disposed beneath the lower surface of the housing whose axis of rotation aligns with the axis of the housing appearing as a number of radial pipe-lines communicating with the ducts of the working fluid supply line, at the ends of which pipe-lines are disposed generators of the high-pressure jets, said generators being arranged in the horizontal and vertical planes at an angle to the header axis; supports adapted to interact with the surface being treated; a reducer, and a piping to feed the working fluid from the high-pressure source to the header, according to the invention, the housing appears as a hollow shaped disk having at least one lower shaped surface and partially filled with a shifting ballast, the housing has a number of ports disposed circumferentially in the central portion thereof, said ports being overlapped with ports similar as to disposing, shape and area and provided in a ring mounted rotatably on the top portion of the housing in the central portion thereof, and the generators of high-pressure jets are mounted on the radial pipe-lines such that an angle β of turn of the axis of the nozzles of said generators in a horizontal plane relative to the axis of the radial pipe-lines in the direction of the rotor rotation exceeds 0°, and the apparatus is further provided with ejector nozzles each of which is disposed on the radial pipe-line of the header at the right angles with a possibility for the header rotor to rotate by virtue of the reaction force arising from the jet of the working fluid discharging from the header, said nozzles being fluidly connected, via a radial pipe-line, to the working fluid feed line; the apparatus is further provided with: a platform carrying supports, said platform being mounted on the stator of the header and disposed beneath the rotor thereof; shaped vanes mounted on the rotor with a possibility of establishing a flow of the working fluid moving from under the lower shaped surface of the housing and directed from the center to the periphery thereof to create a negative pressure underneath the

lower surface of the housing; and a device for changing the direction of motion of the apparatus, the injectors of the generator of high-pressure jets being set at an angle α to the surface being treated such that the borders of the contact pattern of the high-pressure jet of working fluid with the surface being treated, said contact pattern being shaped as an oval whose minor axis is equal to a maximum cross-sectional diameter of the flow body, are defined by the extreme points on the major axis of the ellipse removed from the exit section of the nozzle of the injector of the high-pressure jet generator a distance determinable from the following mathematical relationships:

$$L_{1max} = 0.8\ P_0 \cdot d_0$$

$$L_{2min} = 0.5\ P_0 \cdot d_0$$

where L_{1max} and L_{2min} (mm) state for the maximum and minimum distance, respectively;

P_0 is an inlet pressure of the injector;

d_0 is a minimum diameter of the injector flow section.

[0013] In addition, referring equally to both of the variants of the present invention is the fact that the device for changing the direction of motion of the apparatus may be hydromechanical, e.g., as a number of pairs of ejector nozzles spaced diametrically opposite over the outside surface of the housing and directed oppositely each other, said nozzles having their axes oriented towards the vector of translational motion performed by the apparatus. Besides, said nozzles are fluidly connected, through pipe-lines, to the working fluid feed line and mechanically associated, through a control mechanism, with a control handle, the axes of the ejector nozzles being parallel to each other. The control mechanism of the device for changing the direction of motion of the apparatus comprises a spring-actuated two-position directional control valve for each pair of ejector nozzles, said directional control valve being enclosed in a barrel which communicates the pairs of ejector nozzles with a working fluid feed pipe-line, and being connected, through a control cable, to a control lever disposed on the control handle.

[0014] The device for changing the direction of motion of the apparatus may be hydromechanical, e.g., as a number of unidirectional ejector nozzles spaced diametrically opposite over the outside surface of the housing, the axes of said nozzles being oriented towards the vector of translational motion performed by the apparatus, said nozzles are fluidly connected, through pipe-lines, to the working fluid feed line and mechanically associated, through a control mechanism, with a control handle, the axes of the ejector nozzle being parallel to each other. The control mechanism of the device for changing the direction of motion of the apparatus comprises a spring-actuated two-position directional control valve for each ejector nozzle, said directional control valve being enclosed in a barrel which communicates the pairs of ejector nozzles with a working fluid feed pipe-line, and being connected, through a control cable, to a control lever disposed on the control handle.

[0015] The device for changing the direction of motion of the apparatus may be hydromechanical also in the form of, e.g., hinged ejector nozzles spaced diametrically opposite over the outside surface of the housing and having their axes offset relative to the axis of swivel thereof, said nozzles being mounted, through flanged holders, on hollow stands fluidly connected, via pipelines, to the working fluid feed line and mechanically associated, through a control mechanism, with the control handle.

[0016] The device for changing the direction of motion of the apparatus comprises a pivot-mounted spring-actuated swing cramp-iron having a tooth at one of its ends so as to interact by said tooth or by the end thereof, with a stop dog provided on the flange of the hinged nozzle holder when reversing the hinged nozzle from one working position to the other, and a control cable interconnecting the spring-actuated cramp iron and the control lever disposed on the control handle.

[0017] The apparatus according to both of the variants thereof may be provided with a distribution ring which interconnects circumferentially the radial pipelines of the header rotor, said ring being either a solid structure intercommunicating the pipelines of the header rotor and imparting rigidity thereto, or appearing as a tubular ring header connected to the working fluid feed line and intercommunicating the pipe-lines of header rotor with a possibility of balancing the pressure of the working fluid therein. In this case the shaped vanes may be spaced equally apart along the perimeter of the distribution ring on the outer side thereof.

[0018] Used as the shifting ballast in the apparatus may be water.

[0019] The platform-mounted supports of the apparatus may appear either as conventional wheels, or castor wheels, or spherical or ball supports, or magnetic wheels, or magnetic castor wheels.

[0020] The reducer of the apparatus may appear as a swivel pipe connector disposed on the header stator centrally of the housing so as to communicate the header, via a pipe-line, with a high-pressure source of the working fluid.

[0021] In what follows the invention is illustrated by the accompanying drawings, wherein:

FIG.1 is a plan view of the apparatus according to Variant I of the embodiment thereof;

FIG.2 is a plan view of the apparatus according to Variant II of the embodiment thereof;

FIG.3 is a fragmentarily sectionalized front view of the apparatus;

FIG.4 and FIG.5 is a schematic view of the device

for changing the direction of motion of the apparatus and of the mechanism for its control when is made of pairs of ejector nozzles;

FIG.6 is a plan view of the apparatus showing the device for changing the direction of motion of the apparatus made of unidirectional ejector nozzles;

FIG.7 is a schematic view of a .control mechanism of the unidirectional ejector nozzles;

FIG.8 is a plan view of the apparatus showing the device for changing the direction of motion of the apparatus made of hinged ejector nozzles;

FIG.9 is a fragmentarily sectionalized front view of FIG.8;

FIG.10 and FIG.11 is a schematic view of the control mechanism of the hinged nozzles of FIG.9; and

FIG.12 and FIG.13 give graphic representation of setting angles α and β of the high-pressure jet generators forming a contact pattern on the surface being treated in a vertical and a horizontal plane according to Variant I (α) and Variant II (α and β) of the invention.

[0022] The apparatus for hydrodynamic surface cleaning according to Variant I has a disk-shaped housing 1, a header 2 enclosed centrally in a housing 1 and comprising a stationary-fixed hollow stator 3 arranged along the axis of the housing 1, and a rotor 4 rotatable on the stator 3 and disposed beneath the lower surface of the housing 1.

[0023] The axis of rotation of the rotor 4 aligns with the axis of the housing 1. The rotor 4 appears as a number of radial pipe-lines 5 communicating with the ducts of the working fluid feed line (not shown). Generators 6 of high-pressure jets are provided at the ends of the pipe-lines 5, said generators being disposed at an angle to the axis thereof (i.e., the header axis) in the horizontal and vertical planes. The apparatus has supports 7 adapted to interact with a surface 8 being treated; a reducer 9, and a pipe-line 10 to feed the working fluid from the high-pressure source (not shown) to the header 2.

[0024] The housing 1 appears as a hollow shaped disk having at least one lower shaped surface 11 and partly filled with a shifting ballast 12. A number of ports 12 are disposed circumferentially in the central portion of the housing 1, said ports being overlapped with ports 14 similar as to disposition, shape and area and made in a ring 15 mounted rotatably on the top portion of the housing 1 in the central portion thereof. The apparatus is further provided with a platform 16 carrying supports 7. The platform 16 is disposed on the stator 3 of the header and is arranged beneath the rotor 4 thereof. The apparatus also has shaped vanes 17 mounted on the rotor so as to establish a flow of the working fluid moving from under the lower shaped surface 11 of the housing 1 and directed from the center to the periphery thereof to create a negative pressure underneath the lower surface 11 of the housing 1. Both of the variants of the present invention further comprise a device for changing the direction of motion of the apparatus. The injectors of the generators 6 of high-pressure jets are set at an angle α to the surface being treated such that the borders of the contact pattern of the high-pressure jet of working fluid on the surface being treated, said contact pattern being shaped as an oval whose minor axis is equal to a maximum cross-sectional diameter of the flow body, are defined by the extreme points on the major axis of the ellipse which are removed from the exit section of the nozzle of the injector of the high-pressure jet generator a distance determinable from the following mathematical relationships:

$$L_{1max} = 0.8\, P_0 \cdot d_0$$

$$L_{2min} = 0.5\, P_0 \cdot d_0$$

where L_{1max} and L_{2min} (mm) state for the maximum and minimum distance, respectively;

P_0 is an inlet pressure of the injector;

d_0 is a minimum diameter of the injector flow section.

[0025] The apparatus for hydrodynamic surface cleaning according to Variant II comprises all the features of Variant I of the invention mentioned hereinbefore.

[0026] However, Variant II of the present invention differs from Variant II thereof in that the generators 6 of high-pressure jets are disposed on the radial pipe-lines 5 such that the angle β of turn of the axis of the generator nozzles in a horizontal plane with respect to the axis of the radial pipe-lines 5 in the direction of rotation of the rotor 4 exceeds zero degrees. The apparatus is further provided with ejector nozzles 18 each of which is disposed on the radial pipe-line 5 of the rotor 4 of the header 2 at the right angles to the axis thereof with a possibility for the rotor 4 of the header 2 to rotate by virtue of the reaction force arising from the jet of the working fluid header discharging from the header 2, said nozzles being fluidly connected, via the radial pipe-line 5, to the working fluid feed line (not shown).

[0027] The device for changing the direction of motion of the apparatus may be hydromechanical in both of the variants of the present invention, e.g., as a number of pairs of ejector nozzles 19 spaced diametrically opposite over the outside surface of the housing 1 and directed oppositely each other, said nozzles having their axes oriented towards the vector of translational motion performed by the apparatus. The nozzles 19 are fluidly connected, through pipe-lines 20, to the working fluid feed line (not shown) and mechanically associated, through a control mechanism, with a control handle 21, the axes of the ejector nozzles being parallel to each other. The control mechanism of this particular device for changing the direction of motion of the apparatus comprises a

spring-actuated two-position directional control valve 22 for each pair of ejector nozzles 19, said directional control valve 22 being enclosed in a barrel 23 which communicates the pairs of the ejector nozzles 19 with the working fluid feed pipe-line 20. The directional control valve 22 is mechanically associated, through a control cable 24, to a control lever 25 disposed on the control handle 21.

[0028] The device for changing the direction of motion of the apparatus according to both of the variants thereof may be hydromechanical, e.g., as unidirectional ejector nozzles 26 spaced diametrically opposite apart over the outside surface of the housing 1, the axes of said nozzles being oriented towards the vector of translational motion performed by the apparatus. The nozzles are fluidly connected, through the pipe-lines 20, to the working fluid feed line (not shown) and mechanically associated, through a control mechanism, with the control handle 21. The axes of the ejector nozzle are parallel to each other. The control mechanism of this particular device for changing the direction of motion of the apparatus comprises a spring-actuated directional control valve for each ejector nozzle, said directional control valve 27 for each ejector nozzle 26, said control valve being enclosed in a barrel 28 which communicates each ejector nozzle 26 with the working fluid feed pipe-line 20, and being connected, through the control cable 24, to the control lever disposed on the control handle 21.

[0029] Furthermore, the device for changing the direction of motion of the apparatus according to both of the variants thereof may be hydromechanical also as, e.g., hinged ejector nozzles 29 spaced diametrically apart over the outside surface of the housing 1 and having their axes offset relative to the swivel axis thereof. The nozzles 29 are mounted through holders 30 having flanges 31, on hollow stands 32 fluidly connected, via pipe-lines 33, to the working fluid feed line (not shown) and mechanically associated, through a control mechanism, with the control handle 21. The device for changing the direction of motion of the apparatus has a mechanism for its control which comprises a spring-actuated swing cramp-iron 35 mounted on a pivot 34 and having a tooth 36 at one of its ends. The cramp-iron 35 is adapted to interact through its tooth 36 or through an opposite end 37 thereof with a stop dog 38 provided on the flange 31 of the holder of the hinged nozzle 29 when reversing the hinged nozzle 29 from one working position to the other. The control cable 24 interconnects the spring-actuated cramp- iron 35 and the control lever 25 disposed on the control handle 21.

[0030] The apparatus may be further provided with a distribution ring 37 which interconnects circumferentially the radial pipe-lines 5 of the rotor 4 of the header 2. The distribution ring 37 may be either a solid structure intercommunicating the pipelines 5 of the rotor 4 of the header 2 and imparting rigidity thereto, or appear as a tubular ring header connected to the working fluid feed line (not shown) so as to intercommunicate the pipe-lines 5 of the rotor 4 of the header 2 with a possibility of balancing the pressure of the working fluid therein.

[0031] The shaped vanes 17 may be spaced equally apart along the perimeter of the distribution ring 37 on the outer side thereof. Water may be used as the shifting ballast 12 in the present apparatus.

[0032] The supports 7 mounted on the platform 16 may appear either as conventional wheels, or castor wheels, or spherical or ball supports, or magnetic wheels, or magnetic castor wheels.

[0033] The reducer 9 of the apparatus may appear as, e.g., a swivel pipe connector disposed on the stator 3 of the header 2 centrally of the housing 1 so as to communicate the header 2, via the pipe-line 10, with the high-pressure source (not shown) of working fluid.

[0034] The apparatus of the present invention operates as follows.

[0035] The apparatus is put on the surface to be cleaned to assume a preset vertical position being oriented in the direction of its motion, this being due to the provision of the shifting ballast 12 (e.g., water) held in the interior of the housing 1.

[0036] When the supports 7 are magnetic ones and the surface being treated can be magnetized regardless of where the cleaning operations are carried out, i.e., under water or on land, the apparatus is magnetically held to the surface being treated. If the supports 7 are non-magnetic, or the surface being treated cannot be magnetized, at the initial period of time the apparatus is held on the surface by the operator.

[0037] Then the working fluid is pressure-fed through the pipe-line 10 and the reducer 9 to the interior of the stator 3 of the header 2. It is due to the provision of the reducer 9 as a swivel pipe connector that it can assume a preset vertical position and remains so oriented during any manipulations with the apparatus. Further on the working fluid enters the rotor 4 along the radial pipe-lines 5 and therefrom passes to the working nozzles of the generators 6 of high-pressure jets.

[0038] While discharging from the generators 6 of high-pressure jets positioned at an angle to the surface 8 being treated, according to Variant I of the invention, the working fluid develops a reaction force which causes the header rotor 4 to rotate. According to Variant II of the invention, the working fluid is fed not only to the generators 6 of high-pressure jets the axes of the nozzles of said generators being turned in the direction of rotation of the rotor, i.e., in the direction opposite to the direction of rotation of the rotor 4 but also to the ejector nozzles 18positioned at the right angles to the axis of the pipe-line 5. While discharging from the nozzles 18 the working fluid creates a reaction force which causes the rotor 4 to rotate. A total force that causes the rotor 4 to rotate, according to Variant II of the invention, is defined by a difference between the forces established by the nozzles 18 and by the nozzles of the generators 6 of high-pressure jets.

[0039] The shaped vanes 17 disposed on the rotata-

ble rotor 4 establish a flow of the working fluid moving from under the lower shaped surface 11 of the housing 1 and directed from the center to the periphery thereof to create a negative pressure (rarefaction) underneath the lower surface 11 of the housing 1 due to both a discharge of the working fluid and the fact that lower surface 11 of the housing 1 is shaped under a definite law, which provides for creating an extra force which presses the apparatus against the surface 8 being treated. In case of no magnetic interaction between the supports 7 and the surface 8 said extra forces press the apparatus against the surface 8 being treated so that once the rotor 4 has started rotating, the operator may no longer keep the apparatus forcedly on the surface 8 being treated.

[0040] By rotating the ring 15 one can adjust the amount of overlap of the ports 13 by the ports 14 if the ring 15 by regulating the rate of flow of the working fluid through said ports, thereby adjusting the pressing force applied to the housing 1 of the apparatus.

[0041] While being discharged under pressure from the nozzles of the generators 6 of high-pressure jets, the working fluid shaped into a jet (a cavitating one inclusive) acts upon the foul deposits of the surface 8 being cleaned, thus removing them from said surface and cleaning it due to a many times repeated treatment by the high-pressure jets of the working fluid (due to rotation of the rotor 4) for further use or subsequent treatment.

[0042] According to Variant II of the invention, when the high-pressure jet of the working fluid is directed along with the rotor rotation, the cleaning efficiency is enhanced, insofar as first, the force of action exerted by the high-pressure jet upon the fouls deposits of the surface being cleaned is defined by a sum of the flow velocity of the working fluid high-pressure jet itself and of the rotation speed of the rotor 4 rather than by a difference therebetween which is the case with the Variant I of the invention, and secondly, the high-pressure jet is directed to the base of the deposits so as "to eradicate" them as it were.

[0043] For translational motion of the apparatus over the surface 8 being treated and for various manipulations therewith provision is made in both variants of the invention for a device for changing the direction of motion of the apparatus, said device *per se* may have, e. g., three construction arrangements, with the control mnemonics remaining unaffected in all the variants proposed herein.

[0044] Translational motion of the apparatus is effected due to a reaction force resulting from discharge of the working fluid from the ejector nozzles 19 in one direction, from the unidirectional nozzles 26, and from the hinged ejector nozzles 29. Whenever it becomes necessary to turn the apparatus to one side or another on the surface being treated, or to turn it around on the spot, the operator depresses the lever 25 on the control handle 21, thus acting upon through the control cable 24, or on the spring-actuated two-position directional control valve 22, or on the spring-actuated directional control valve 27, or on the spring-actuated swing cramp-iron 35.

[0045] In the first case the two-position directional control valve 22 moves in the barrel 23 to shut off one of the nozzles 19 in the pair and to turn on the other nozzle thereof. When the direction of the discharge of the working fluid from the nozzle 19 of the second pair of nozzles, a moment of forces is developed on the apparatus to turn it to a required direction.

[0046] In the second case directional control valve 27 also effects control over the feed of the working fluid to either of the nozzles 26 in the pair, and the processes proceeding as a result are similar to those described above. Partial shutting off of either of the nozzles 76 causes the apparatus to turn along a preset pathway and setting the apparatus on a parallel track to be cleaned in a reverse direction.

[0047] In the third case the control cable 24 causes the tooth 36 of the spring-actuated swing cramp-iron 35 to disengage the stop dog 38. The hinged nozzle 29 is urged by the reaction force resulting from the working medium discharging from said nozzle to turn through 180 degrees from one working position to the other until the opposite end 37 of the cramp-iron 35 is engaged with said stop-dog 38.

[0048] As a result, a moment of forces is developed on the apparatus, resulting from differently directed position of the nozzles 29, said moment causing said nozzle to turn, thus changing the direction of its further motion. Once the maneuver has been over, the operator presses again the lever 25 on the control handle 21 to turn the cramp-iron 35, whereby its end 37 disengages the stop-dog 38, and the nozzle 29 returns to the initial position as in the previous operation, and the apparatus keeps performing rectilinear motion in another direction.

[0049] The herein-proposed apparatus is made from standard construction materials using routine production processes and can therefore be manufactured under standard production conditions.

Claims

1. An apparatus for hydrodynamic surface cleaning comprising a disk-shaped housing, a header accommodated centrally in the housing and consisting of a stationary fixed stator arranged along the housing axis, and a rotor rotating on the stator and disposed beneath the lower surface of the housing whose axis of rotation aligns with the axis of the housing appearing as a number of radial pipe-lines communicating with the ducts of the working fluid supply line, at the ends of which pipe-lines are disposed generators of the high-pressure jets, said generators being arranged in the horizontal and vertical planes and at an angle to the header axis; supports adapted to interact with the surface being

treated; a reducer, and a piping to feed the working fluid from the high-pressure source to the header, **CHARACTERIZED In that** the housing appears as a hollow shaped disk having at least one lower shaped surface and partially filled with a shifting ballast, the housing has a number of ports disposed circumferentially in the central portion thereof, said ports being overlapped with ports similar as to disposing, shape and area and provided in a ring mounted rotatably on the top portion of the housing in the central portion thereof; the apparatus is further provided with: a platform carrying supports, said platform being mounted on the stator of the header and disposed beneath the rotor thereof; shaped vanes mounted on the rotor with a possibility of establishing a flow of the working fluid moving from under the lower shaped surface of the housing and directed from the center to the periphery thereof to create a negative pressure underneath the lower surface of the housing; and a device for changing the direction of motion of the apparatus, the injectors of the generator of high-pressure jets being set at an angle α to the surface being treated such that the borders of the contact pattern of the high-pressure jet of working fluid with the surface being treated, said contact pattern being shaped as an oval whose minor axis is equal to a maximum cross-sectional diameter of the flow body, are defined by the extreme points on the major axis of the ellipse removed from the exit section of the nozzle of the injector of the high-pressure jet generator a distance determinable from the following mathematical relationships:

$$L_{1max} = 0.8\ P_0 \cdot d_0$$

$$L_{2min} = 0.5\ P_0 \cdot d_0$$

where L_{1max} and L_{2min} (mm) state for the maximum and minimum distance, respectively;

P_0 is an inlet pressure of the injector;

d_0 is a minimum diameter of the injector flow section.

2. An apparatus for hydrodynamic surface cleaning comprising a disk-shaped housing, a header accommodated centrally in the housing and consisting of a stationary fixed stator arranged along the housing axis, and a rotor rotating on the stator and disposed beneath the lower surface of the housing whose axis of rotation aligns with the axis of the housing appearing as a number of radial pipe-lines communicating with the ducts of the working fluid supply line, at the ends of which pipe-lines are disposed generators of the high-pressure jets, said generators being arranged in the horizontal and vertical planes at an angle to the header axis; supports adapted to interact with the surface being treated; a reducer, and a piping to feed the working fluid from the high-pressure source to the header, **CHARACTERIZED In that** the housing appears as a hollow shaped disk having at least one lower shaped surface and partially filled with a shifting ballast, the housing has a number of ports disposed circumferentially in the central portion thereof, said ports being overlapped with ports similar as to disposing, shape and area and provided in a ring mounted rotatably on the top portion of the housing in the central portion thereof, and the generators of high-pressure jets are mounted on the radial pipe-lines such that an angle β of turn of the axis of the nozzles of said generators in a horizontal plane relative to the axis of the radial pipe-lines in the direction of the rotor rotation exceeds 0° , and the apparatus is further provided with ejector nozzles each of which is disposed on the radial pipe-line of the header at the right angles with a possibility for the header rotor to rotate by virtue of the reaction force arising from the jet of the working fluid discharging from the header, said nozzles being fluidly connected, via a radial pipe-line, to the working fluid feed line; the apparatus is further provided with: a platform carrying supports, said platform being mounted on the stator of the header and disposed beneath the rotor thereof; shaped vanes mounted on the rotor with a possibility of establishing a flow of the working fluid moving from under the lower shaped surface of the housing and directed from the center to the periphery thereof to create a negative pressure underneath the lower surface of the housing; and a device for changing the direction of motion of the apparatus, the injectors of the generator of high-pressure jets being set at an angle α to the surface being treated such that the borders of the contact pattern of the high-pressure jet of working fluid with the surface being treated, said contact pattern being shaped as an oval whose minor axis is equal to a maximum cross-sectional diameter of the flow body, are defined by the extreme points on the major axis of the ellipse removed from the exit section of the nozzle of the injector of the high-pressure jet generator a distance determinable from the following mathematical relationships:

$$L_{1max} = 0.8\ P_0 \cdot d_0$$

$$L_{2min} = 0.5\ P_0 \cdot d_0$$

where L_{1max} and L_{2min} (mm) state for the maximum and minimum distance, respectively;

P_0 is an inlet pressure of the injector;

d_0 is a minimum diameter of the injector flow

section.

3. An apparatus as claimed in claim 1 or claim 2, **CHARACTERIZED in that** a device for changing the direction of motion of the apparatus is hydromechanical, e.g., as a number of pairs of ejector nozzles spaced diametrically opposite over the outside surface of the housing and directed oppositely each other, said nozzles having their axes oriented towards the vector of translational motion performed by the apparatus. Besides, said nozzles are fluidly connected, through pipe-lines, to the working fluid feed line and mechanically associated, through a control mechanism, with a control handle, the axes of the ejector nozzles being parallel to each other.

4. An apparatus as claimed in claim 3, **CHARACTERIZED in that** a control mechanism of the device for changing the direction of motion of the apparatus comprises a spring-actuated two-position directional control valve for each pair of ejector nozzles, said directional control valve being enclosed in a barrel which communicates the pairs of ejector nozzles with a working fluid feed pipe-line, and being connected, through a control cable, to a control lever disposed on the control handle.

5. An apparatus as claimed in claim 1 or claim 2, **CHARACTERIZED in that** the device for changing the direction of motion of the apparatus is hydromechanical, e.g., as a number of unidirectional ejector nozzles spaced diametrically opposite over the outside surface of the housing, the axes of said nozzles being oriented towards the vector of translational motion performed by the apparatus, said nozzles are fluidly connected, through pipe-lines, to the working fluid feed line and mechanically associated, through a control mechanism, with a control handle, the axes of the ejector nozzle being parallel to each other.

6. An apparatus as claimed in claim 5,**CHARACTERIZED in that** the control mechanism of the device for changing the direction of motion of the apparatus comprises a spring-actuated directional control valve for each pair of ejector nozzles, said directional control valve being enclosed in a barrel which communicates the pairs of ejector nozzles with a working fluid feed pipe-line, and being connected, through a control cable, to a control lever disposed on the control handle.

7. An apparatus as claimed in claim 1 or claim 2, **CHARACTERIZED in that** the device for changing the direction of motion of the apparatus is hydromechanical also in the form of, e.g., hinged ejector nozzles spaced diametrically opposite over the outside surface of the housing and having their axes offset relative to the axis of swivel thereof, said nozzles being mounted, through flanged holders, on hollow stands fluidly connected, via pipe-lines, to the working fluid feed line and mechanically associated, through a control mechanism, with the control handle.

8. An apparatus as claimed in claim 7, **CHARACTERIZED in that** the device for changing the direction of motion of the apparatus comprises a pivot-mounted spring-actuated swing cramp-iron having a tooth at one of its ends so as to interact by said tooth or by the end thereof, with a stop dog provided on the flange of the hinged nozzle holder when reversing the hinged nozzle from one working position to the other, and a control cable interconnecting the spring-actuated cramp iron and the control lever disposed on the control handle.

9. An apparatus as claimed in claim 1 or claim 2, **CHARACTERIZED in that** it is provided with a distribution ring which interconnects circumferentially the radial pipe-lines of the header rotor, said ring being either a solid structure intercommunicating the pipelines of the header rotor and imparting rigidity thereto, or appearing as a tubular ring header connected to the working fluid feed line and intercommunicating the pipe-lines of header rotor with a possibility of balancing the pressure of the working fluid therein.

10. An apparatus as claimed in claim 9, **CHARACTERIZED in that** the shaped vanes are spaced equally apart along the perimeter of the distribution ring on the outer side thereof.

11. An apparatus as claimed in claim 1 or claim 2, **CHARACTERIZED in that** used as the shifting ballast therein is, e.g., water.

12. An apparatus as claimed in claim 1 or claim 2, **CHARACTERIZED in that** the supports disposed on the platform appear as wheels.

13. An apparatus as claimed in claim 1 or claim or claim 12, **CHARACTERIZED in that** the supports disposed on the platform appear as castor wheels.

14. An apparatus as claimed in claim 1 or claim 2, **CHARACTERIZED in that** the supports disposed on the platform appear as spherical or ball supports.

15. An apparatus as claimed in claim 1 or claim 2, **CHARACTERIZED in that** the supports disposed on the platform are magnetic supports.

16. An apparatus as claimed in claim 1 or claim 2 or claim 12, **CHARACTERIZED in that** the supports

disposed on the platform appear as magnetic wheels.

17. An apparatus as claimed in claim 1 or claim 2 or claim 12 or claim 13, **CHARACTERIZED in that** the supports disposed on the platform appear as magnetic castor wheels.

18. An apparatus as claimed in claim 1 or claim 2, **CHARACTERIZED in that** the reducer appears as a swivel pipe connector disposed on the header stator centrally of the housing so as to communicate the header, via a pipe-line, with a source of high-pressure working fluid.

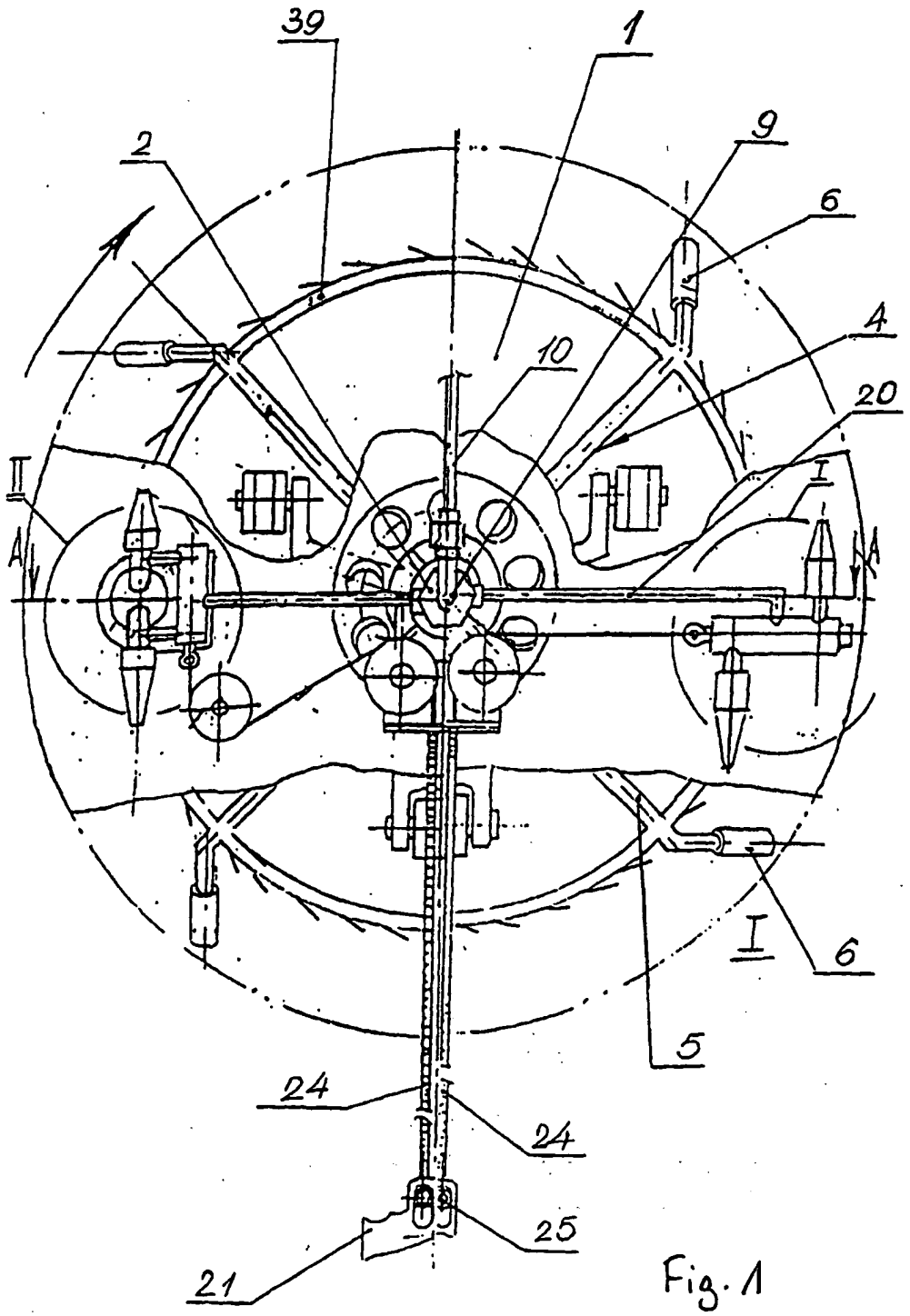

Fig. 1

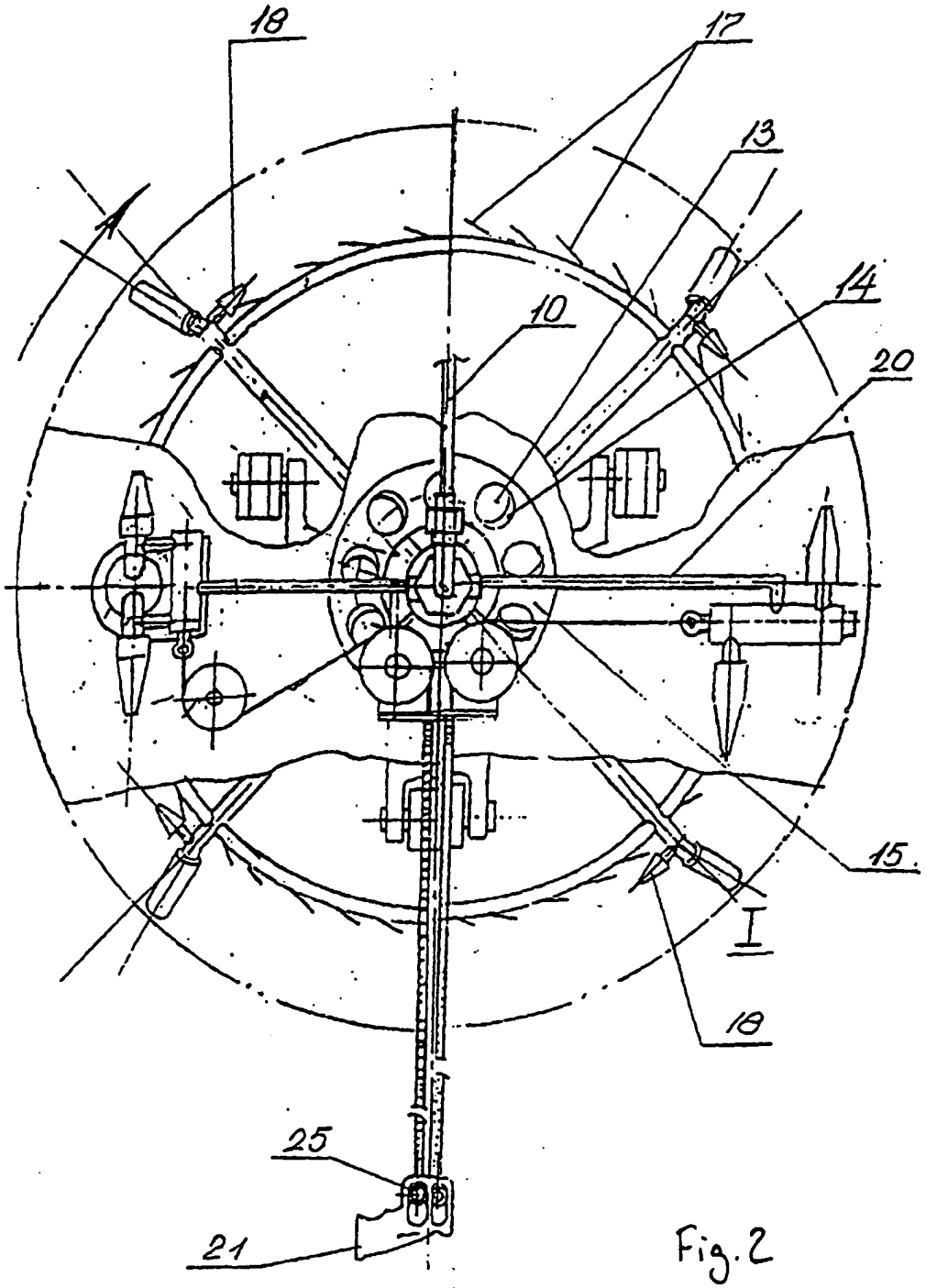

Fig. 2

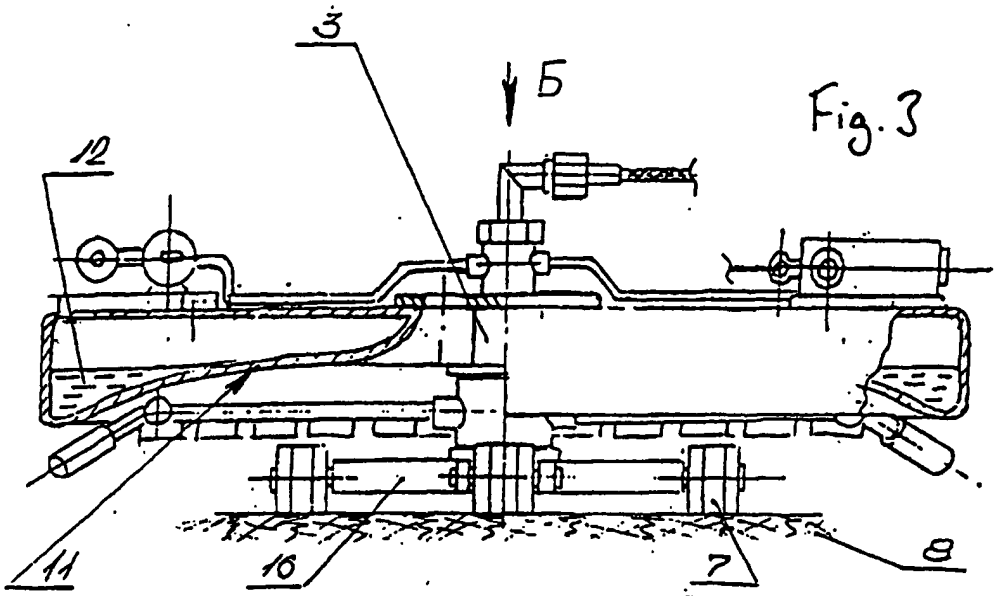

Fig. 3

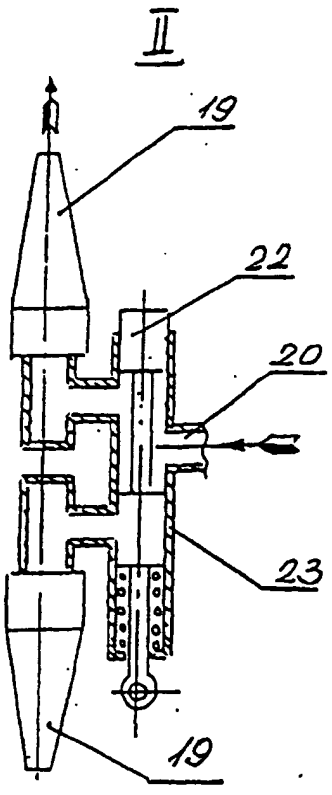

Fig. 4

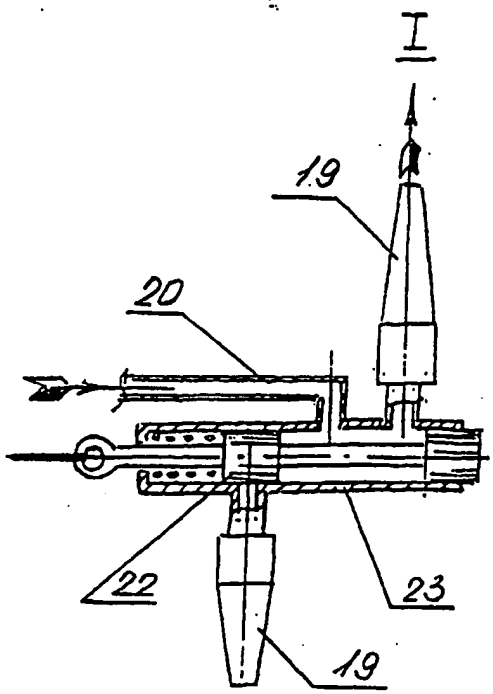

Fig. 5

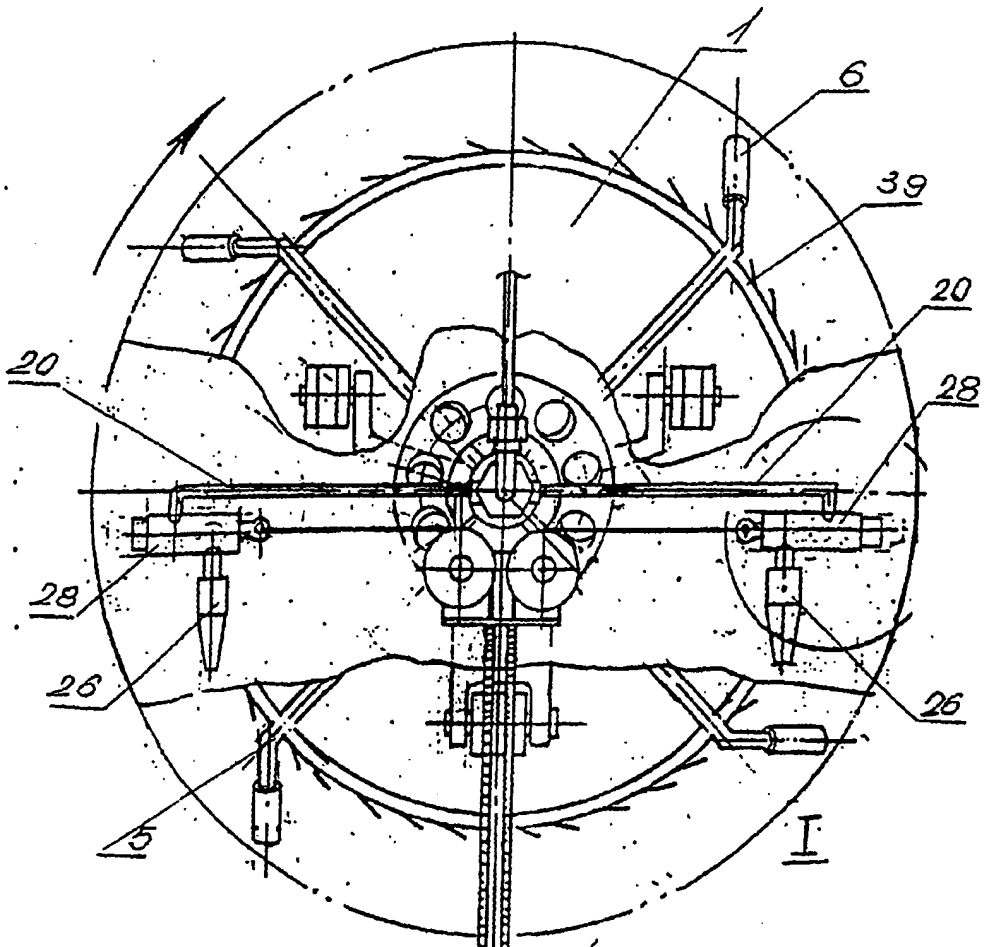

Fig. 6

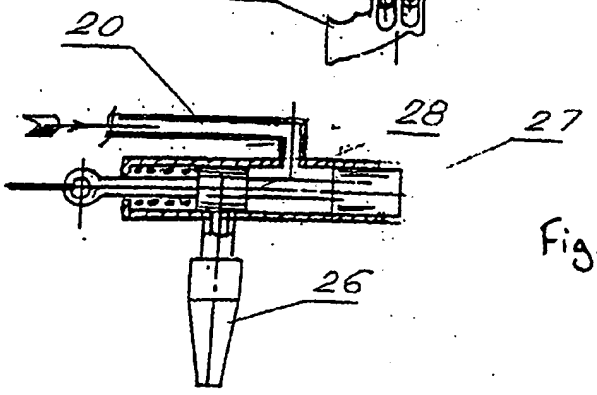

Fig. 7

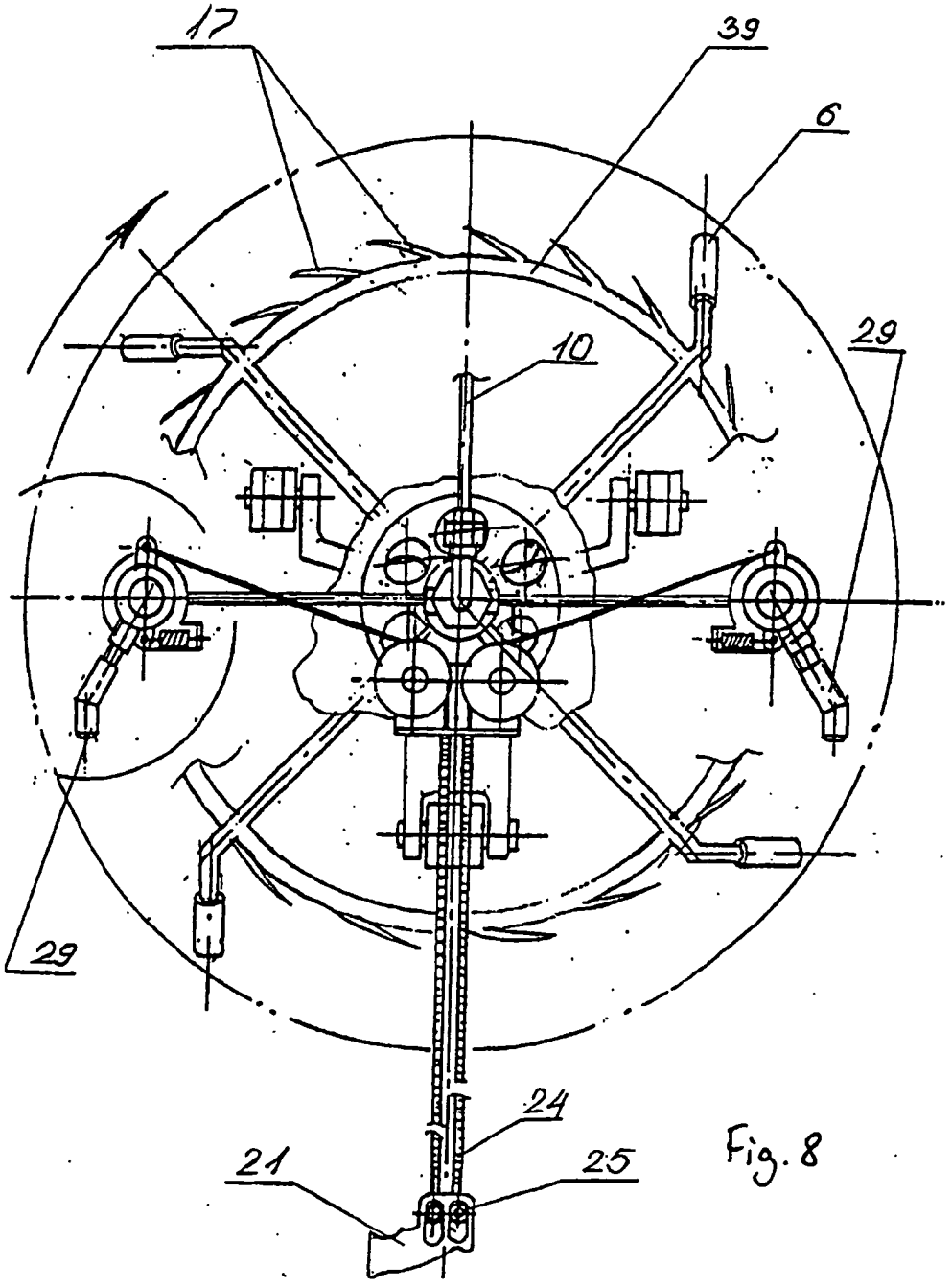

Fig. 8

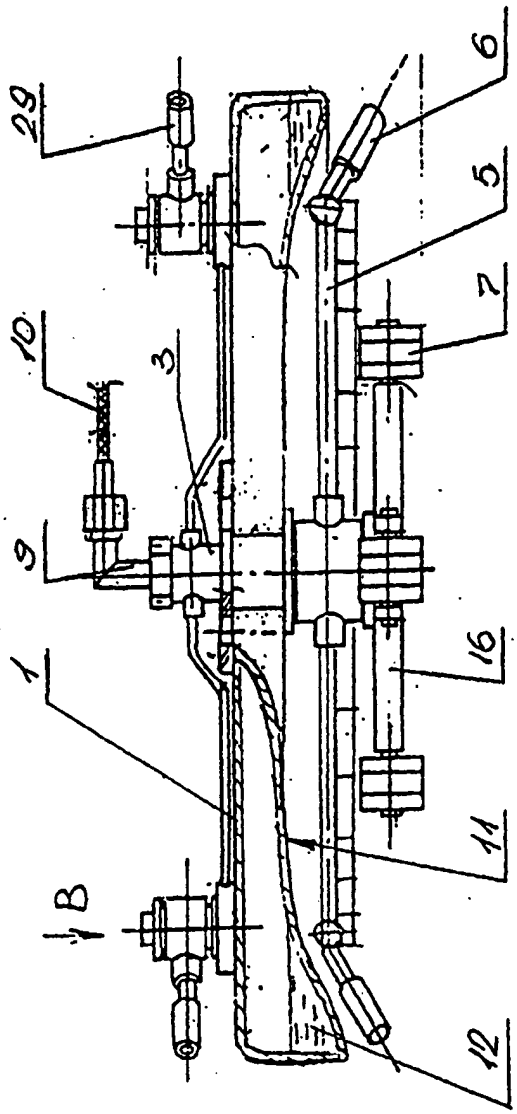

Fig. 9

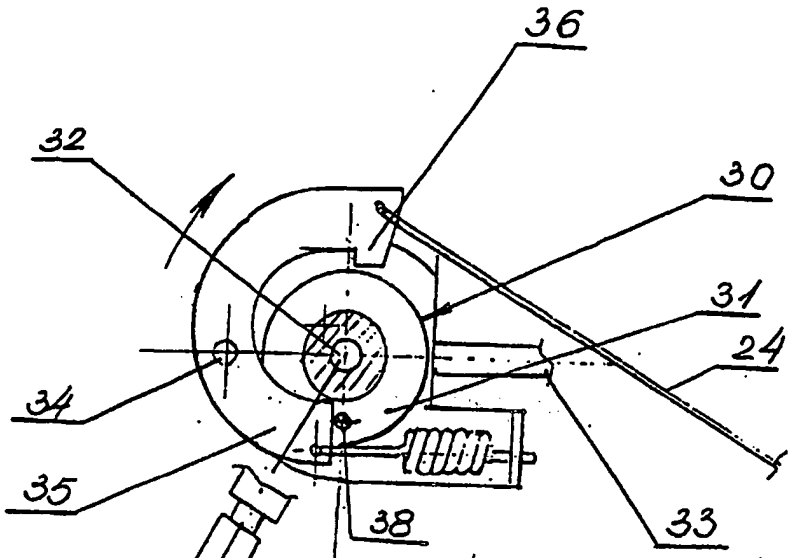

Fig. 10

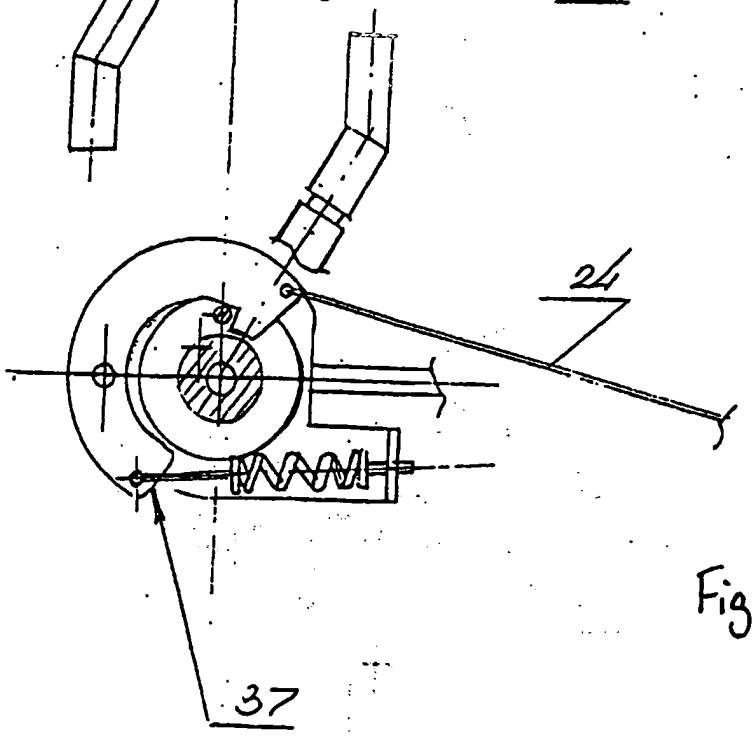

Fig. 11

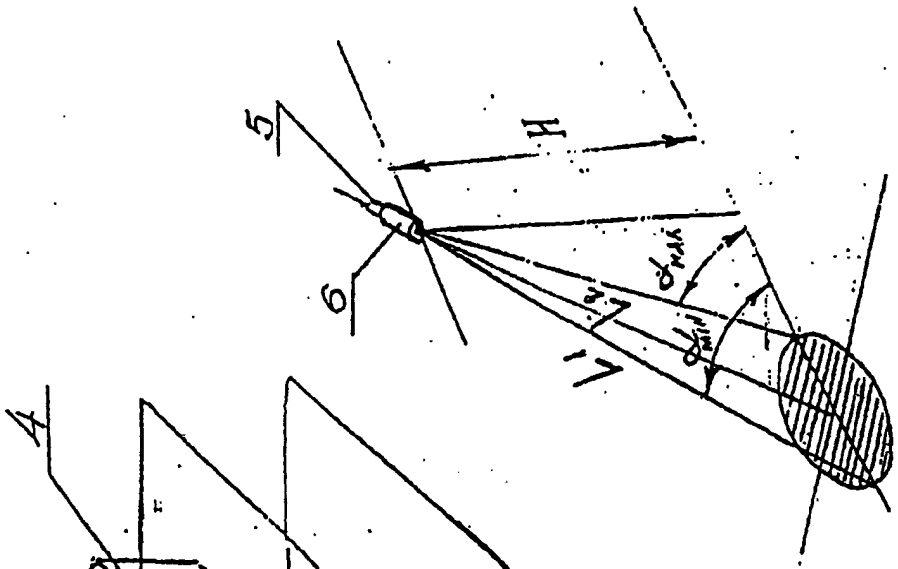

Fig.13

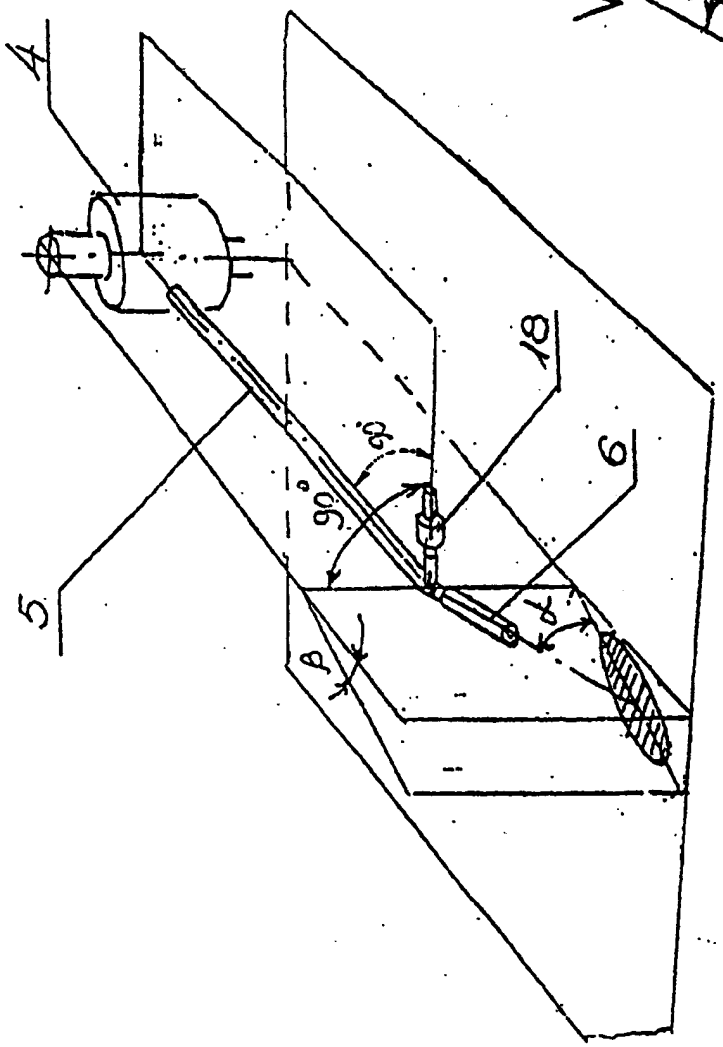

Fig.12

INTERNATIONAL SEARCH REPORT

International application No. PCT/RU 99/00277

A. CLASSIFICATION OF SUBJECT MATTER
IPC7: B08B 3/02, B63B 59/08 B63C 11/52
According to International Patent Classification (IPC) or to both national classification and IPC B

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC7 : B63B 59/00, 59/06, 59/08, B08B 3/02, 3/04, B63C 11/52

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	RU 2002524 C1 (KHABAROVSKY POLITEKHNICHESKY INSTITUT) 15 November 1993 (15.11.93), the abstract, the claims	1-18
A	RU 2101103 C1 (MOSKOVSKY GOSUDARSTVENNY UNIVERSITET PRIKLADNOI BIOTEKHNOLOGII) 10 Janvier 1998 (10.01.98), the abstract, the description, column 4	1-18
A	WO 82/02368 A1 (ORAM STEPHEN W.) 22 July 1982 (22.07.82), page 6	1-18
A	US 4926775 A (JOHN P. ANDORSEN) 22 May 1990 (22.05.90), the abstract	1-18

☐ Further documents are listed in the continuation of box C. ☐ Patent family members are listed in annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
10 April 2000 (10.04.00)	27 April 2000 (27.04.00)
Name and mailing address of the ISA/RU RU	Authorised officer Telephone No.

Form PCT/ISA/210 (second sheet) (July 1992)

ОТЧЕТ О МЕЖДУНАРОДНОМ ПОИСКЕ

Международная заявка № PCT/RU 99/00277

А. КЛАССИФИКАЦИЯ ПРЕДМЕТА ИЗОБРЕТЕНИЯ:

B08B 3/02, B63B 59/08 B63C 11/52

Согласно международной патентной классификации (МПК-7)

В. ОБЛАСТИ ПОИСКА:

Проверенный минимум документации (система классификации и индексы) МПК-7:

B63B 59/00, 59/06, 59/08, B08B 3/02, 3/04, B63C 11/52

Другая проверенная документация в той мере, в какой она включена в поисковые подборки:

Электронная база данных, использовавшаяся при поиске (название базы и, если, возможно, поисковые термины):

С. ДОКУМЕНТЫ, СЧИТАЮЩИЕСЯ РЕЛЕВАНТНЫМИ:

Категория*	Ссылки на документы с указанием, где это возможно, релевантных частей	Относится к пункту №
A	RU 2002524 C1 (ХАБАРОВСКИЙ ПОЛИТЕХНИЧЕСКИЙ ИНСТИТУТ) 15.11.93, реферат, формула изобретения	1-18
A	RU 2101103 C1(МОСКОВСКИЙ ГОСУДАРСТВЕННЫЙ УНИВЕРСИТЕТ ПРИКЛАДНОЙ БИОТЕХНОЛОГИИ) 10.01.98, реферат, описание, кол. 4	1-18
A	WO 82/02368 A1 (ORAM STEPHEN W.) 22 July 1982, стр.6	1-18
A	US 4926775 A (JOHN P. ANDORSEN) May 22, 1990, реферат	1-18

☐ последующие документы указаны в продолжении графы С. ☐ данные о патентах-аналогах указаны в приложении

* Особые категории ссылочных документов:

A документ, определяющий общий уровень техники

E более ранний документ, но опубликованный на дату международной подачи или после нее

O документ, относящийся к устному раскрытию, экспонированию и т.д.

P документ, опубликованный до даты международной подачи, но после даты испрашиваемого приоритета и т.д.

T более поздний документ, опубликованный после даты приоритета и приведенный для понимания изобретения

X документ, имеющий наиболее близкое отношение к предмету поиска, порочащий новизну и изобретательский уровень

Y документ, порочащий изобретательский уровень в сочетании с одним или несколькими документами той же категории

& документ, являющийся патентом-аналогом

Дата действительного завершения международного поиска: 10 апреля 2000 (10.04.2000)	Дата отправки настоящего отчета о международном поиске: 27 апреля 2000 (27.04.2000)
Наименование и адрес Международного поискового органа: Федеральный институт промышленной собственности Россия, 121858, Москва, Бережковская наб., 30-1 Факс: 243-3337, телетайп: 114818 ПОДАЧА	Уполномоченное лицо: В. Бернадский Телефон № (095)240-25-91

Форма PCT/ISA/210 (второй лист)(июль 1998)